Lecture Module - Introduction

ME3023 - Measurements in Mechanical Systems

Mechanical Engineering

Tennessee Technological University

Topic 1 - Introduction

Module 1 - Introduction

- Topic 1 - General Measurement System
- Topic 2 - Types of Variables
- Topic 3 - Experimental Test Plan
- Topic 4 - Numbers and Storage

Topic 1 - General Measurement System

- Definition of a Measurement
- Measurement System Stages
- Brainstorming Activity
- Examples in Mechcanical Engineering

Definition of a Measurement

"A **measurement** is an act of assigning a specific value to a physical variable."

Text: Theory and Design of Mech. Meas.

Measurement System Stages

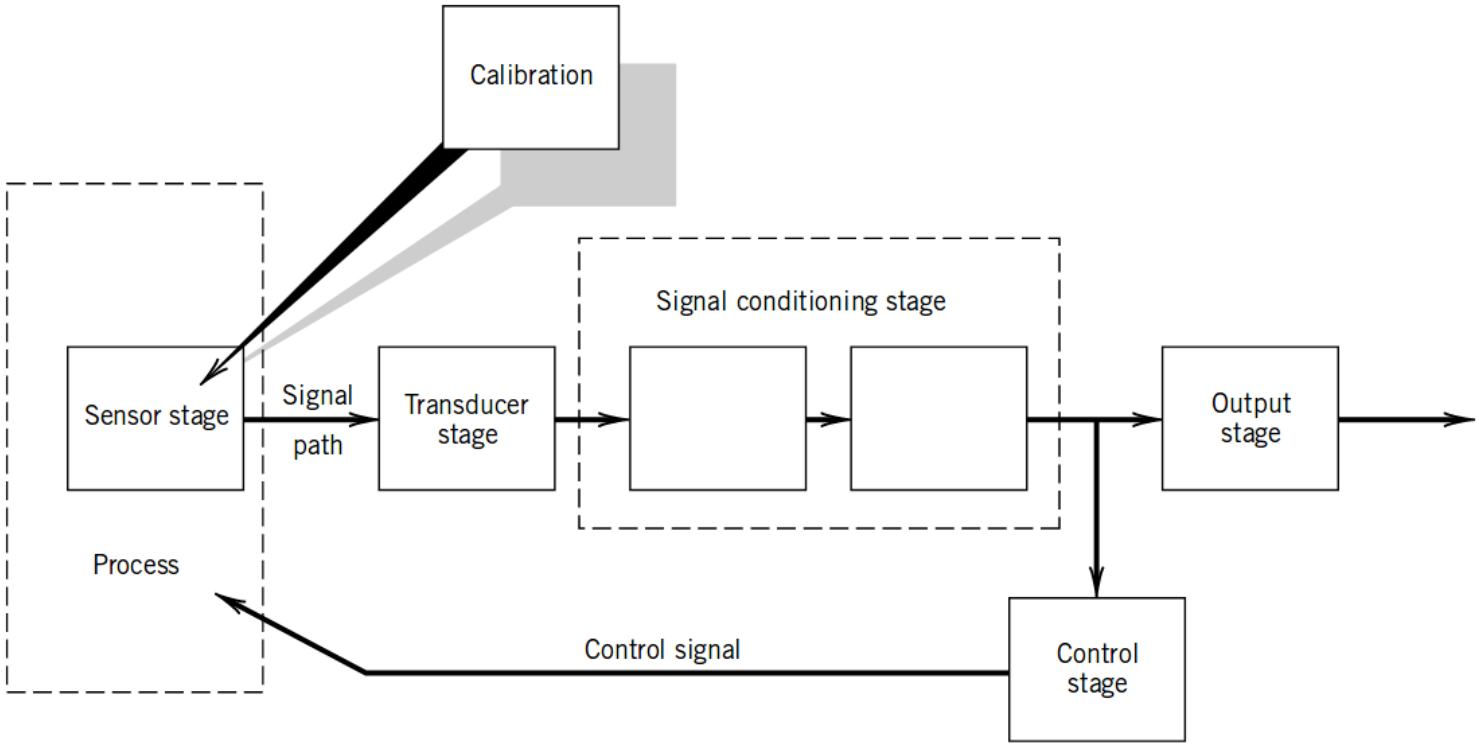
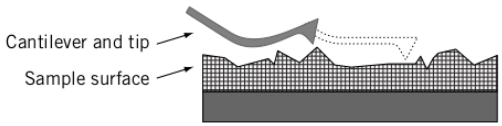


Figure 1.5 Components of a general measurement system.

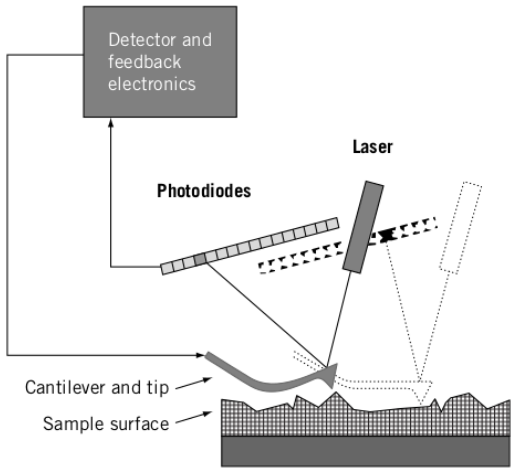
Image: Theory and Design of Mech. Meas.

Sensor-Transducer Stage

a sensor, a physical element that employs some natural phenomenon... ...to sense the variable being measured



Sensor Stage

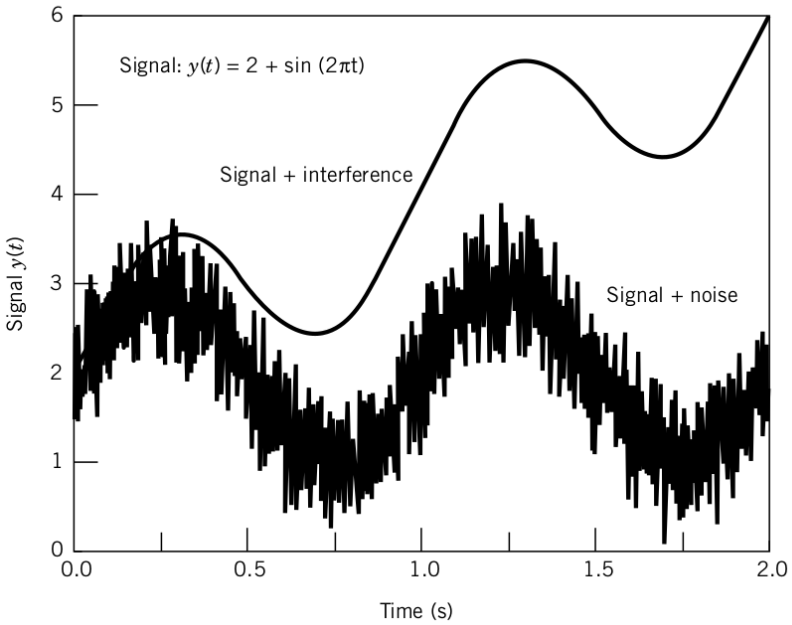


Sensor + Transducer Stage

A transducer converts sensed information into a detectable signal

Text, Image: Theory and Design of Mech. Meas.

Signal Conditioning Stage



- Filtering
- Amplification
- Attenuation
- Excitation
- Linearization
- Electrical Isolation
- Surge Protection

Question: What is the the definition of signal?

Image: Theory and Design of Mech. Meas.

Defintion of a signal

Signal (noun): *4 a : an object used to transmit or convey information beyond the range of human voice b : the sound or image conveyed in telegraphy, telephony, radio, radar, or television c : a detectable physical quantity or impulse (such as a voltage, current, or magnetic field strength) by which messages or information can be transmitted* - Merrian Webster

In signal processing, a signal is a function that conveys information about a phenomenon.[1] Any quantity that can vary over space or time can be used as a signal to share messages between observers.[2] The IEEE Transactions on Signal Processing includes audio, video, speech, image, sonar, and radar as examples of signals.[3] A signal may also be defined as any observable change in a quantity over space or time (a time series), even if it does not carry information. - Wikipedia

Output Stage

The output stage indicates or records the value measured. This might be a simple readout display, a marked scale, or even a recording device such as a computer disk drive.

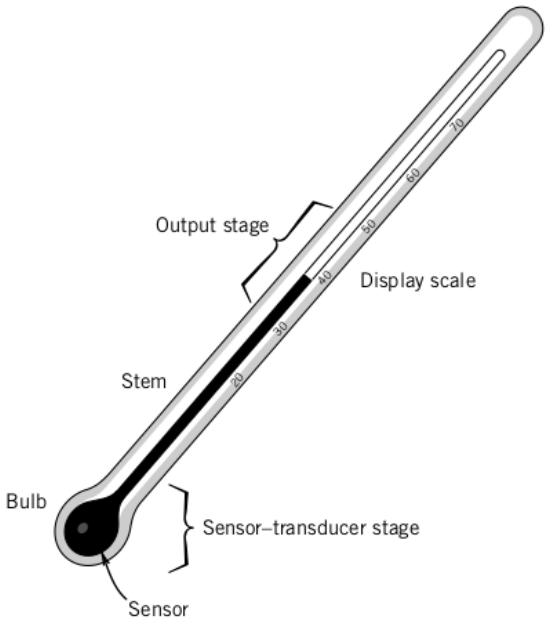


Image: Theory and Design of Mech. Meas.

Image: Wikipedia

Brainstorming Activity

Activity: Team Brainstorm
Duration: $\sim$ 10 minutes
Groups: 2-3 members

Topic: Remote Probe Concept

- You are designing a remote probe to inspect an environment which can only be accessed from above.
- The goal is to collect as much information as possible from the environment to prepare for a robotic maintinence task.

Requirements:

- Probe must enter environment through hole $\sim 100mm$ wide
- Probe must exit through same hole leaving nothing behind
- The alllowable EFI and RFI is limited. No wifi communication is available

Examples in Mechcanical Engineering

IDETC2022-96785: Development of an Instrumented Rear Suspension to Measure the Tire Forces of a Race Car During Track Driving

Examples in Mechcanical Engineering

IDETC2022-91154: Photometric Stereo Enhanced Light Sectioning Measurement for Microtexture Road Profiling

Examples in Mechcanical Engineering

IDETC2022-90082: Automated Weld Path Generation Using Random Sample Consensus and Iterative Closest Point Workpiece Localization

Topic 2 - Types of Variables

- Measured Variable
- Independent and Dependent Variables
- Controlled Variables and Parameters
- Extraneous Variables

Measured Variable

"A measurement is an act of assigning a specific value to a physical variable. That physical variable is the measured variable."

Text: Theory and Design of Mech. Meas.

Independent and Dependent Variables

"If a change in one variable will not affect the value of some other variable, the two are considered independent of each other. A variable that can be changed independently of other variables is known as an independent variable. A variable that is affected by changes in one or more other variables is known as a dependent variable. Normally, the variable that we measure depends on the value of the variables that control the process."

Text: Theory and Design of Mech. Meas.

Controlled Variables and Parameters

"A variable is controlled if it can be held at a constant value or at some prescribed condition during a measurement... ...complete control of a variable is not usually possible. We use the adjective controlled to refer to a variable that can be held as prescribed, at least in a nominal sense...

...we define a parameter as a functional grouping of variables. For example, a moment of inertia or a Reynolds number... ...A parameter that has an effect on the behavior of the measured variable is called a control parameter...."

Text: Theory and Design of Mech. Meas.

Extraneous Variables

"Variables that are not or cannot be controlled during measurement but that affect the value of the variable measured are called extraneous variables. Their influence can confuse the clear relation between cause and effect in a measurement... ...The effects due to extraneous variables can take the form of signals superimposed onto the measured signal with such forms as noise and drift."

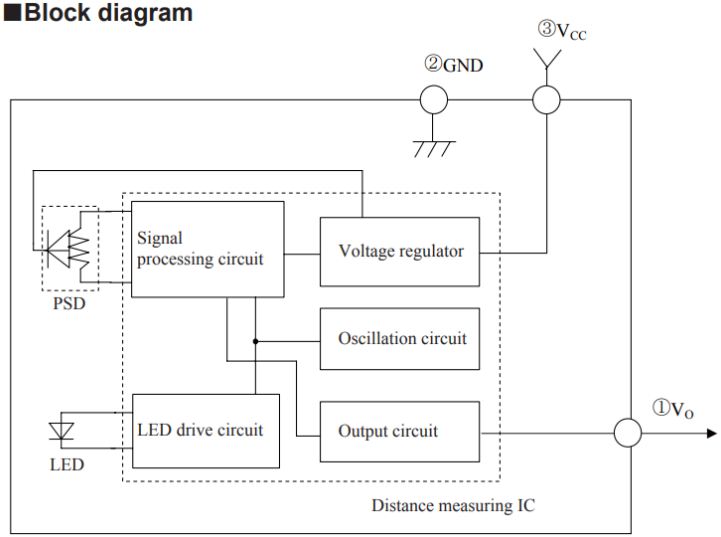
Text: Theory and Design of Mech. Meas.

Class Activity: Measurement System Examples

Indiviual Activity: Complete the activity and submit your work on ilearn *as an indiviual*.

Example 1: SHARP IR Ranger

■Block diagram



Image, More Info: Wikipedia-proximity sensor
Image, More Info: Wikipedia-PSD

Identify the following measurement stages

- Sensor: _____
- Transducer: _____
- Signal Conditioning: _____
- Output: _____

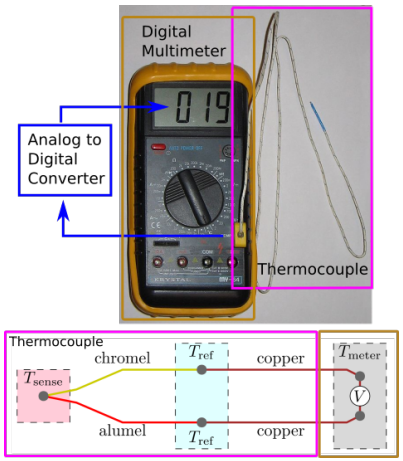
Name at least one for each of the following categories

- Measured Variable: _____
- Independent Variable(s): _____
- Dependent Variable(s): _____, _____
- Controlled Variable(s): _____, _____
- Extraneous Variable(s): _____

Class Activity: Measurement System Examples

Indiviual Activity: Complete the activity and submit your work on ilearn *as an individual*.

Example 2: Thermocouple with DMM



Identify the following measurement stages

- Sensor: _____
- Transducer: _____
- Signal Conditioning: _____
- Output: _____

Name at least one for each category

- Measured Variable: _____
- Independent Variable(s): _____, _____
- Dependent Variable(s): _____, _____
- Controlled Variable(s): _____
- Extraneous Variable(s):_____

Image, More Info: Wikipedia-Thermocouple Image, More Info: Omega-Ktype Thermocouple

Topic 3 - Experimental Test Plan

- Parameter Design Plan
- System and Tolerance Design Plan
- Data Reduction Design Plan
- Experimental Design Strategies

Parameter Design Plan

Parameter Design Plan: Determine the test objective and identify the process variables and parameters and a means for their control.

Ask:

- What question am I trying to answer?
- What needs to be measured?
- What variables and parameters will affect my results?

Text: Theory and Design of Mech. Meas.

System and Tolerance Design Plan

System and Tolerance Design Plan: Select a measurement technique, equipment, and test procedure based on some preconceived tolerance limits for error.

Ask:

- In what ways can I do the measurement?
- How good do the results need to be to answer my question?

Text: Theory and Design of Mech. Meas.

Data Reduction Design Plan

Data Reduction Design Plan: Plan how to analyze, present, and use the anticipated data.

Ask:

- How will I interpret the resulting data?
- How will I use the data to answer my question?
- How good is my answer?
- Does my answer make sense?

Text: Theory and Design of Mech. Meas.

Experimental Design Strategies

- Randomized Tests
- Repetition and Replication.
- Concomitant Methods

Small Group Activity

Group Activity: Find a group of 2-3 students. Complete the activity and submit your work on ilearn *as an indiviual*. You may submit the same or similar answers as your group members.

Experimental Test Plan: Fuel/Energy Economy

1. Develop an experimental test plan for determining the milage cost of your vehicle (choose any vehicle) in dollars per mile. Write a short desciption of the system. (paragraph or bulleted list)
2. Identify the following variables for your plan.
   - Measured Variable:
   - Independent Variable(s):
   - Dependent Variable(s):
   - Controlled Variable(s):
   - Extraneous Variable(s):
3. Do you expect the results of the study to represent the true milage of the vehicle? How could you validate (or check) the results?
4. What could you do to improve the results of the proposed study?

Image, More Info: Wikipedia